

*Where in the (World Wide) Web of Belief
is the Law of Non-contradiction?**

JACK ARNOLD

The Ohio State University

STEWART SHAPIRO

The Ohio State University

University of St. Andrews

It is sometimes said that there are two, competing versions of W. V. O. Quine's unrelenting empiricism, perhaps divided according to temporal periods of his career. According to one, the empiricism relents a little. Logic is exempt from, or lies outside the scope of, the attack on the analytic-synthetic distinction. This *logic-friendly* Quine holds that logical truths and, presumably, logical inferences are analytic in the traditional sense: they are true solely in virtue of the meaning of the logical terminology. Consequently, logical truths are knowable a priori, and, importantly, they are incorrigible, and so immune from revision. No amount of empirical data can get us to revise them. The logic-friendly Quine argues that this concession exhausts the scope of analyticity.

2 The other, *radical* version of Quine does not exempt logic from the attack on analyticity and a priority. Logical truths and inferences are themselves part of the web of belief, and the same global methodology applies to logic as to any other part of the web, such as theoretical chemistry or ordinary beliefs about ordinary objects. Everything, including logic, is up for grabs in

*Acknowledgments: Many thanks to Louise Antony, J. C. Beall, Hartry Field, Fraser MacBride, Robert Meyer, Otavio Bueno, Graham Priest, Agustín Rayo, Mark Steiner, Neil Tennant, and Crispin Wright. Thanks also to the Arché Centre at the University of St. Andrews, the Society for Exact Philosophy, the Oxford Philosophical Society, the Hebrew University Philosophy Colloquium, and the Buffalo Logic Colloquium for devoting sessions to this paper.

our struggle for holistic confirmation. The scientist just might come to revise the basic principles and inferences of logic, to bring her beliefs into line with observation. If the empirical going gets rough enough, it might be rational to do so.

There are different things one might mean by “revising logic”.¹ One rather uncontroversial thesis is that it might become rational to alter our *theory of logic*. There is nothing radical about this. Logical theory has been disputed, and has changed, over the ages, from Aristotle, through the medieval logicians, to Gottlob Frege, David Hilbert, Alfred Tarski, L. E. J. Brouwer, etc. On the contemporary scene, the intuitionist, the relevantist, and the classical logician (among others) disagree over what the canons of correct inference are. Each holds that the other is mistaken—and always was. The radical Quine adds, however, that like any other scientific enterprise, logical theory can be revised as a result of *empirical* considerations, as a response to surprising and difficult observations.

In addition to this, the radical Quine adopts a deeper sense of logical revisability. He holds that in the web of belief, correct inference itself, and not just our theory of correct inference, is up for revision. The radical Quine holds that a certain logical principle, such as the law of excluded middle or the law of non-contradiction, can be an essential part of the web of belief at one time, *accurately* describing allowed inferences at that time. Consequently, any theory of logic (at that time) that does not sanction this principle is an incorrect theory. Yet the logical principle in question might be later dropped or altered, as the best response to a series of unexpected observations. That is, the radical Quine holds that (correct) inferential practices themselves can change in response to observations.

It is not easy to summarize this position into a coherent slogan. The key thought is that the methodology of science allows one to revise the basic principles of correct inference, along the same lines as one revises the directly empirical parts of science. But what can this mean, if not that it is *consistent* with the methodology of science to revise the canons of correct inference, in response to recalcitrant data? But there is no notion of consistency that is independent of logic. Consider the law of non-contradiction.² It cannot be consistent with the methodology of science to believe a contradiction, just because it is not consistent to believe a contradiction. That's what consistency is, as the term is used now, as we try to state the thesis adopted by the radical Quine.

We propose to waive this matter, and just assume, at least for the sake of argument, that we know what the radical Quine means (but see Shapiro [2000]). If we cannot get this grain of salt, then there is not much point in trying to further assess the view.

The purpose of this paper is to examine the law of non-contradiction, and the concomitant principle of *ex falso quodlibet*, from the perspective of the principles advocated by the radical Quine. We show that he has no

compelling reason to accept either of these. To put it bluntly, neither the law of non-contradiction nor the rule of ex falso quodlibet is empirically confirmed, and these principles fare poorly on the various criteria for theory acceptance on the methodology of the radical Quine. So the radical Quine is led rather quickly and rather directly into something in the neighborhood of Graham Priest's dialetheism (e.g., [1987]). We leave it to the reader to decide whether to go with the radical Quine and Priest, or to dismiss the radical Quine.

For what it is worth, our own sympathies are with classical logic, at least when it comes to mathematics. Classical logic is accepted by the vast majority of the world's logicians, and we count ourselves among their number, without apology. Most classical logicians do not see themselves as proposing a revision of inferential practice. Rather, the typical classical logician takes herself to be *describing* the inferential norms that underlie at least contemporary mathematics, and not advocating new, better norms to replace those (cf. Burgess [1992], Shapiro [1998]). However, the considerations toward this conclusion typically invoke notions that are foreign to the radical Quine's enterprise. The classical logician speaks in terms of the *necessary* preservation of truth, truth under all *interpretations*, the *meaning* of the logical terminology, etc. The topic of the present paper is to assess classical logic in terms of the criteria adopted by the radical Quine. It does not fare well.

The project is not primarily exegetical, aimed at understanding what Quine was up to. For what it is worth, however, we think that the radical Quine is the real Quine. It will serve our purposes to rehearse passages from Quine's work that support each interpretation. It turns out that it is not a temporal matter, separating the early, brash Quine (of, say, "Two dogmas of empiricism" [1951]) from his more sober, mature time-slices (e.g., [1986]). There are passages supporting both interpretations throughout the corpus, sometimes in the same work, separated by a few paragraphs. No matter how the overall exegetical issue is adjudicated, our first goal is to learn something about the radical Quine by seeing how he understands the passages that seem to support the logic-friendly interpretation.

1 Quine versus Quine. The original attack on the analytic-synthetic distinction in the early sections of "Two dogmas" (Quine [1951]) begins by separating the supposedly analytic truths into two groups, those that are logically true and those that can be turned into logical truths by substituting synonyms for synonyms. The rest of the argument shows how problematic the notion of synonymy is, along with related notions. So the reader can be left with the impression that there are no problems with the notion of logical truth and, presumably, logical inference.

Of course, the fact (if it is a fact) that Quine does not explicitly attack the notion of logical truth in the first five sections of "Two dogmas" does not entail that he was happy with attributing the traditional properties of analytic truths to logical truths. But if he had an argument against the analyticity or a priority of logic, he did not present it there.

What Quine provides instead is an alternate picture, in the positive account in the concluding Section 6. There, logic is explicitly brought into the holistic fold. The opening of that section is probably the most quoted passage in the corpus:

The totality of our so-called knowledge or beliefs, from the most casual matters of geography and history to the profoundest laws of atomic physics or even of pure mathematics and logic, is a man-made fabric which impinges on the experience only along the edges. Or, to change the figure, total science is like a field of force whose boundary conditions are experience. A conflict with experience at the periphery occasions readjustments in the interior of the field. Truth values have to be redistributed over some of our statements. Reevaluation of some statements entails reevaluation of others, because of their logical interconnections—the logical laws being in turn simply certain further statements of the system, certain further elements of the field. Having reevaluated one statement we must reevaluate some others, which may be statements logically connected with the first or may be the statements of the logical connections themselves.

The metaphor near the start of the passage indicates the special role of logic in the web of belief. Logic provides the principles that regulate the acceptance and rejection of beliefs, given other acceptances and rejections. This is the traditional role of logic, as concerned with consequence, and thus with correct inference.

At this point, one would expect an account of how this role for logic plays itself out in the pragmatic web of belief. Logic, it seems, regulates traffic in the web. Instead, we are told that logical laws are just certain statements *in* the web.³ The end of the passage is an explicit statement that logical principles are themselves thrown into the mix in our drive for equilibrium. This is the radical Quine *par excellence*. A few lines later, the holistic theme is repeated, with logic now in direct focus:

... it becomes folly to seek a boundary between synthetic statements, which hold contingently on experience, and analytic statements, which hold come what may. Any statement can be held true come what may, if we make drastic enough adjustments elsewhere in the system. Even a statement very close to the periphery can be held true in the face of recalcitrant experience by pleading hallucination or by amending certain statements of the kind called logical laws. Conversely, by the same token, no statement is immune to revision. Revision even of the logical law of excluded middle has been proposed as a means of simplifying quantum mechanics; and what difference is there between such a shift and the shift whereby Kepler superseded Ptolemy, or Einstein Newton, or Darwin Aristotle.

The logic-friendly Quine seems to appear (or reappear) in Chapter 2 of *Word and Object* [1960], when we are told, in effect, that the truth-functional connectives are exempt from the indeterminacy of translation. We *must* translate others as accepting our logic. Quine finds it incoherent to think that there

might be a “pre-logical” people who do not agree with us about the rules of logic:

To take the extreme case, let us suppose that certain natives are said to accept as true certain sentences translatable in the form ‘ p and not p ’. Now this claim is absurd under our semantic criteria. And, not to be dogmatic about them, what criteria might one prefer? Wanton translation can make natives sound as queer as one pleases. Better translation imposes our logic upon them, and would beg the question of prelogicality, if there were a question to beg.

The idea here is that anybody who contradicts himself deliberately is incoherent. If we are not to attribute this horrible incoherence to the natives, we must translate them as accepting the law of non-contradiction. In short, the law of non-contradiction is built into the very canons of correct translation. It goes to the heart of rationality itself. Given that, what else is there to say, but that the law of non-contradiction is analytic, and known *a priori*?⁴

The logic-friendly theme appears again in *Philosophy of Logic* [1986, 81]:

... what if someone were to reject the law of non-contradiction and so accept an occasional sentence and its negation both as true? An answer one hears is that this would vitiate all science. Any conjunction of the form ‘ $p \sim p$ ’ logically implies every sentence whatever; therefore acceptance of one sentence and its negation as true would commit us to accepting every sentence as true, and thus forfeiting all distinction between true and false.

In answer to this answer, one hears that such full-width trivialization could perhaps be staved off by making compensatory adjustments to block this indiscriminate deducibility of all sentences from an inconsistency. Perhaps, it is suggested, we can so rig our new logic that it will isolate its contradictions and contain them.

My view of this dialogue is that neither party knows what he is talking about. They think they are talking about negation, ‘ $\sim$ ’, ‘not’; but surely the notation ceased to be recognizable as negation when they took to regarding some conjunctions in the form ‘ $p \sim p$ ’ as true, and stopped regarding such sentences as implying all others. Here, evidently, is the deviant logician’s predicament: when he tries to deny the doctrine he only changes the subject.

Quine here alludes to the development of paraconsistent logic, well underway in Australia, Brazil, Pittsburgh, and other places, during Quine’s career. Quine has the “deviant” logician following the procedure described in “Two dogmas”. She decides to reevaluate a logical principle, the law of non-contradiction, and this “entails” reevaluation of something else, the rule of *ex falso quodlibet*. What’s the problem? Quine says that the logician has “changed the subject”. The new connective is not the *negation* we know and love, despite the fact that it has a similar shape, and some similar inferential features. What can Quine mean here, except that the law of non-contradiction

is part of the *meaning* of negation? It is analytic, or analytic of the negation we use. Quine's remark here runs against the grain of the radical Quine. How can a Quinean, much less Quine himself, allow a distinction in kind between a change in the meaning of a word and a change in beliefs?

The same sentiment is expressed in his "Two dogmas in retrospect" [1991, 270], concerning another logical principle:

...what are we to say of revisions, such as imagined in the case of the law of excluded middle? Do we thereby change our theory or just change the subject, change the meaning of our words? This has been a recurrent challenge, and my answer is that in elementary logic a change of theory *is* a change of meaning. Repudiation of the law of excluded middle would be a change of meaning, and no less a change of theory for that.

A few sentences later, the radical Quine reasserts himself:

... I have been expressing a generous attitude toward analyticity that may seem out of character. In fact my reservations over analyticity are the same as ever, and they concern the tracing of any demarcation, even a vague and approximate one, across the domain of sentences in general. (Quine [1991, 271])

Part of the key to unraveling the puzzle comes a few paragraphs later: "I recognize the notion of analyticity in its obvious and useful but epistemologically insignificant applications. The needs that Carnap felt for the notion in connection with mathematical truth are better met through holism." A similar thought was expressed much earlier, in *Words and objections* [1969, 324]:

It should be clear that my ventures at defining logical and mathematical truth are and have been epistemologically neutral. I am concerned to demarcate the class of logical or mathematical truths, as I might the class of chemical truths; not to show how or why the evidence for truths in the class differs from the evidence for other truths.

Holism, of course, is another key Quinean theme. Items in the web of belief do not face experience alone, but only in groups. The logic-friendly Quine exempts logic from the tribunal of experience, but the real, radical Quine does not. At the end of *Philosophy of logic* [1986, 100], he writes:

Mathematics and logic are supported by observation only in the indirect way that those aspects of natural science are supported by observation; namely as participating in an organized whole which, way up at its empirical edges, squares with observation. I am concerned to urge the empirical character of logic and mathematics no more than the unempirical character of theoretical physics; it is rather their kinship that I am urging, and a doctrine of gradualism

Logic is in principle no less open to revision than quantum mechanics or the theory of relativity. The goal is, in each, a world system—in Newton's phrase—that

is as smooth and simple as may be and that nicely accommodates observations around the edges. If revisions are seldom proposed that cut so deep as to touch logic, there is a clear enough reason for that: the maxim of minimal mutilation.

So what are we to make of the apparently logic-friendly talk of a change of logic being a change of subject, a change in meaning? Why is Quine allowing a distinction between change in subject and change in theory?

In the early pages of *Word and object* [1960], Quine concedes that his critics were right to object to the “excessive holism” in “Two dogmas”: “Some middle-sized scrap of theory usually will embody all the connections that are likely to affect our adjudication of a given sentence” (Quine [1960, 13]). The point here, we submit, is that logic is an exception to this conceded moderation of holism: “... the logical truths at least, as no doubt many more commonplace sentences too, are germane to all topics and thus provide connections”. Quine thus claims that a change in logic would engender changes throughout the web, so much so that we might as well think of ourselves as speaking a new language altogether. We thus have a rough and ready distinction between change of meaning and change of belief, but this marks only a difference in degree, not a difference in kind, and the difference does not mark anything significant for epistemology.⁵

2 Traffic in the web. The focus, so far, is on logical truth. We still need an account of *inference* in the web of belief. We take it that, for Quine, logic guides the process of reevaluating sentences, but what is to guide logic? How should we proceed when logic principles themselves are being reevaluated—when the very extension of “logical consequence” is up for grabs? We need an account of correct inference that somehow transcends the particular logic in place now, and is compatible with a change in logic.

Let us briefly return to the pivotal passage from §6 of “Two dogmas”:

A conflict with experience at the periphery occasions readjustments in the interior of the field. Truth values have to be redistributed over some of our statements. Reevaluation of some statements entails reevaluation of others, because of their logical interconnections... Having reevaluated one statement we must reevaluate some others...

The first sentence is in indicative mode, making a statement about what happens. As a generalization about scientific and everyday practices, it is surely true, for the most part. But the other sentences in the passage are modal. How are we to understand Quine’s statements that truth values *have to be* redistributed, that one reevaluation *entails* others, and that if we reevaluate one statement, we *must* reevaluate others?

The logic-friendly Quine has a ready answer to these questions. The “must” is that of logical consequence. Logic codifies the norms of correct inference that hold in all subject matters, under all circumstances. But the radical Quine

does not have this answer available. According to him, we *are* allowed to contemplate a change in logic, if the flow of experience suggests such a move. Again, what does “allowed” mean? That is a modal notion, too. It cannot mean that it is *consistent* to change logic, and, say, believe a contradiction, since it clearly isn’t.

It has been often noted that normativity is potentially problematic in the Quinean world view. Our issue now concerns what (the radical) Quine means when he *uses* the traditional normative notions associated with logical inference. What, exactly, is it that compels the revisions that we *have to make*, once we change a belief?

We might add that Quine is skeptical of modality generally: “We should be within our rights in holding that no part of science is definitive so long as it remains couched in idioms of ... modality ... Such good uses as the modalities are ever put to can probably be served in ways that are clearer and already known ...” (Quine [1986,33-34]). In the passages above, we see Quine using modal notions. “Truth values have to be redistributed over some of our statements.” It is fair to wonder how he understands those passages, in non-modal “ways that are clearer and already known”.

The opening pages of *Word and object* [1960] follow the lead of a previous empiricist, David Hume. Quine considers a case study: a chemist “mixes the contents of two test tubes, observes a green tint, and says ‘There was copper in it.’” Quine notes that the chemist’s conclusion is “elicited by a non-verbal stimulus, but the stimulus depends for its efficacy upon an earlier network of associations of words with words; viz., one’s learning of chemical theory”. According to the radical Quine, the driving force in the chemist’s reasoning is *conditioning*:

There are so-called logical connections, and there are so-called causal ones; but any such interconnections of sentences must finally be due to the conditioning of sentences as responses to sentences as stimuli. If some of the connections count more particularly as logical or as causal, they do so only by reference to so-called logical or causal laws which in turn are sentences within the theory. The theory as a whole—a chapter of chemistry, in this case, plus relevant adjuncts from logic and elsewhere—is a fabric of sentences variously associated to one another and to non-verbal stimuli by the mechanism of conditioned response.

Theory may be deliberate, as in a chapter on chemistry, or it may be second nature, as is the immemorial doctrine of ordinary enduring middle-sized physical objects. In either case, theory causes a sharing, by sentences, of sensory inputs. (Quine [1960, 11])

Behavioral and verbal conditioning is a descendant of Hume’s notion of “custom”. We make connections between sentences because we have been conditioned to. In some cases, the conditioning is deliberate, mediated via theory; in other cases conditioning is second-nature. We take the word “causes” in

Quine's last sentence literally. The conclusions of arguments *happen*; they are *caused* by the premises. Or, to be more precise, acceptance of the premises causes acceptance of the conclusion.

Suppose that a scientist adopts a theory according to which all crows have lungs. As a result, she is conditioned to say, or think, "that creature has a lung" once she identifies the creature as a crow. We are all conditioned to say, or think, "There is a seminar today", once we have come to believe "Today is Wednesday", and "There is a seminar every Wednesday".

A related idea is expressed in the final section of "Two dogmas", perhaps a bit less explicitly. There Quine notes that the first description of the web of belief speaks of varying "distances" from the "periphery". He tries to clarify the idea, "without metaphor":

Certain statements, though *about* physical objects and not sense experience, seem peculiarly germane to sense experience . . . Such statements, especially germane to particular experiences, I picture as near the periphery. But in this notion of "germaneness" I envisage nothing more than a loose association reflecting the relative likelihood, in practice, of our choosing one statement rather than another for revision in the event of recalcitrant experience.

We do indeed use logic to regulate traffic in the web. But for the radical Quine, logic is not the ultimate traffic cop, since logic is just part of the web itself, up for revision by the same methodology as anything else. The underlying traffic cop is the scientist's conditioned responses to verbal and non-verbal inputs. This, of course, is nicely consonant with his notorious behaviorism. A philosopher who is attracted to the radical holism, and radical empiricism, but does not accept the aforementioned basis in conditioning owes us some other account of how moves are made in the web of belief, especially when logic itself is up for revision.⁶

3 Recalcitrance. One final matter of interpretation, and we will have enough of the radical Quine on the table. We are told that revisions in the web of belief are engendered by "recalcitrant" data. What does the radical Quine mean by "recalcitrant"? Suppose that a scientist makes an observation, which prompts her to utter, or believe, a sentence *P*. What is it for *P*, or the observation that promoted it, to be recalcitrant with, or be in conflict with, her other beliefs?

The intuitive and perhaps obvious answer is that the sentence *P* is recalcitrant for our scientist if she is otherwise committed to $\neg P$. For example, $\neg P$ may be a logical consequence of a theory she adopts.

To be sure, the radical Quine can, and probably does, hold that right now, we detect recalcitrance via contradictions. Nothing problematic about that, as a description of our current practice, with our current logic (assumed to be classical). But this cannot be what it is to be recalcitrant. If it were, then the law of non-contradiction would be built into the bedrock of scientific

methodology itself. If recalcitrance just *is* contradiction, then it would conflict with scientific methodology to accept a contradiction. Quite literally, there would be no possibility of revising the law of non-contradiction. Any contradiction is *automatically* recalcitrant. How can a piece of data get us to accept a contradiction in order to rid ourselves of recalcitrance, when the presence of a contradiction among our beliefs is itself recalcitrant? In short, if $\neg P$ is automatically in conflict with P , then the law of non-contradiction is analytic, and unrevisable.

As a second attempt, let us say that a sentence is recalcitrant for a speaker if she is disposed to deny it or otherwise dissent from it. And an observation is recalcitrant for a speaker if it prompts assent to a sentence she is otherwise disposed to deny or dissent from. This defines recalcitrance in causal, behavioral terms, much in line with Quine's underlying philosophy. Following Priest [1987, Chapter 7, §7.3], we take dissent or denial to be a speech act, expressing the rejection of the indicated sentence. Similarly, assertion is a speech act expressing acceptance. Presumably, it is not possible to accept and reject the same sentence, at the same time. Among other things, rejection of a sentence involves refusing to accept it, and it seems to be impossible to hold and refuse to hold the same sentence, at the same time. So if one is disposed to accept a sentence and disposed to refuse to accept it, then there is tension. Note that the tension here is not logical, in the sense that one is both disposed and not disposed to do the same thing. The tension involved with recalcitrance is that it is impossible to *fulfil* one's dispositions. One is disposed to do the impossible. So revisions are needed to relieve the tension.

We are not out of these woods yet. Quine [1960, 57] holds that dissenting from a (short) sentence just is to accept its negation: "The semantic criterion of negation is that it turns any short sentence to which one will assent into a sentence from which one will dissent, and vice versa". If this semantic criterion is right, and if it is indeed impossible to accept and reject the same sentence at the same time, then the law of non-contradiction is, once again, incorrigible (albeit on non-logical grounds). Quine's "semantic criterion for negation" makes it impossible to accept a contradiction. Once again, we see that any contradiction automatically generates tension, and so the law of non-contradiction is not really up for grabs in the holistic drive for equilibrium, even in principle.

It seems that our radical Quinean must demur from Quine's "semantic criterion for negation", or at least she must hold that the semantic criterion is itself up for revision. If rejection, or dissent, is divorced from acceptance-of-negation, then the law of non-contradiction is indeed now up for grabs, in principle. But then talk of assent and rejection do not provide an account of recalcitrance.

We submit that the radical Quine must understand recalcitrance in terms of verbal and non-verbal conditioning, along the same lines as he understands the flow of inference through the web. We thus propose to characterize

recalcitrance directly in terms of internal tension. Say that an observation is recalcitrant for a speaker/theorist, just in case it prompts her to revise some of her beliefs, changing truth values. Of course, an observation is not (automatically) recalcitrant for a subject just because it prompts him to accept a sentence he had no opinion on before. Adding to the stock of sentences one is disposed to assert does not engender recalcitrance. On the view in question, an observation is recalcitrant only if accepting it causes the speaker to *change* his opinion of other sentences. It should cause him to declare that a sentence is true that he thought false, or vice versa. And a sentence is recalcitrant just in case accepting it as true would prompt the speaker to revise other beliefs.

This seems to be a legitimate notion for the radical Quine to employ, since it does not (automatically) make the law of non-contradiction, or any other logical principle analytic or beyond revision. On this interpretation, logical principles are indeed up for grabs in the drive for equilibrium in the web of belief, at least in principle. As above, someone attracted to the confirmational holism and radical empiricism who does not accept Quine's unrelenting behaviorism is free to propose another account of recalcitrance, one that leaves the revision of the law of non-contradiction a genuine possibility. In this paper, we will stick to the foregoing notion.

4 Non-contradiction and ex falso quodlibet. We now turn to the place of the law of non-contradiction in the web of belief. This goes hand in glove with the inference of ex falso quodlibet: $P, \neg P \models Q$. If there are no true contradictions, then ex falso quodlibet is truth-preserving. It is not possible for the premises $P, \neg P$ to be true and the conclusion Q false for the simple reason that it is not possible for the premises to be true.⁷ We submit that non-contradiction and ex falso quodlibet do not fare well on the radical Quine's acknowledged criteria for determining the contents of the web and determining how belief revision takes place.

As we saw just above, in *Word and object*, Quine wrote: "Theory may be deliberate, as in a chapter on chemistry, or it may be second nature, as is the immemorial doctrine of ordinary enduring middle-sized physical objects" (Quine [1960, 11]). There may be orientations intermediate between "second nature" and "deliberate", but we do not consider those here. We propose to approach non-contradiction and ex falso quodlibet from each of the two polar perspectives. The results are quite different, but they reinforce each other. To put it bluntly, we submit that by the lights embraced by the radical Quine, these two principles of logic are highly *disconfirmed*, but in a different way depending on how they are understood.

4.1 Second nature. Let us first see if we can make sense of the law of non-contradiction and the inference ex falso quodlibet along the lines of, or as parts of, "the immemorial doctrine of ordinary enduring middle-sized physical objects". The thesis at hand is that our two principles hold pre-theoretically. Due to our ages-old practice of confronting the world and trying to make sense of it, via language, we automatically invoke these principles.

They were in place before we began developing sophisticated scientific and logical theories, and they inform and underlie these same theories. Of course, even if this is correct, it does not make the logical principles any less fallible or any less open to revision. Even the immemorial doctrine of ordinary enduring middle-sized objects is subject to revision, if the going gets rough enough. And when it comes to the sub-atomic, the going has gotten pretty rough lately.

Just above, we saw how (the radical) Quine understands logical and non-logical inference in terms of conditioning (§2). Following this lead, we interpreted recalcitrance in terms of dispositions to revise one's beliefs (§3). So on the present model, the law of non-contradiction is a statement that contradictions are recalcitrant, in this sense. The claim is that humans have evolved to a state in which it is second-nature for them to feel tension in their belief system whenever they find themselves believing, or disposed to believe, sentences in the form P and $\neg P$. If we find ourselves believing a contradiction, we are disposed to revise our beliefs, and do not rest content until there is no contradiction anywhere in the web of belief.⁸

From the present perspective, the law of non-contradiction amounts to a (mere) generalization concerning human dispositions. At this point, it is fair to ask if the generalization is true. *Are* we so disposed that we feel tension whenever we encounter a contradiction among our beliefs?

To be sure, *some* contradictions, and some types of contradiction, would generate tension in any sane person's belief set—and we have no problem limiting the scope of the generalization to the sane. If someone has accepted a theory that entails that there are no black swans, and has an observation that disposes her to believe that there is a black swan, then she had better look to revise her beliefs, on pain of irrationality. Surely, there is tension in this belief set.

Moreover, there very well might be some people for whom the law of non-contradiction is a true generalization. Such folks do in fact feel tension, and become disposed to revise, whenever they realize that they have contradictory beliefs. We like to think of ourselves that way, but perhaps this is just vanity or self-deception. But our question here is whether the generalization is true for all sane beings. Is the law of non-contradiction second-nature, at the level of generality needed for it to be a "law"?

We submit that it is not. Some philosophers and mathematicians have developed extensive, putatively consistent responses to standard paradoxes like that of the liar, the heap, Burali-Forti, Richard, Grelling, etc., but most human beings, including some who are paradigms of sanity, express no more than mild amusement at these paradoxes. They pursue their other theoretic and practical projects with calm equanimity. Well, perhaps there is some sort of division of labor. The bulk of the intellectual world admits that the paradoxes are problematic, but they leave it to experts—us philosophers—to resolve them, just as they leave it to experts in physics to resolve the tension

induced by wave-particle duality. In the case at hand, this is silly. Most of sane humanity just does not care about the semantic paradoxes. They engender no tension whatsoever, and they do not care much what we philosophers say about them.

To take another, perhaps more serious example, seventeenth and eighteenth century mathematicians, whose sanity and rationality can hardly be challenged, accepted and worked with an inconsistent theory of infinitesimals. They simply felt no tension. George Berkeley's logically penetrating critique of the calculus did not dispose the mathematicians to do any revising. Other examples from science and religion are not hard to find. Mark Steiner [1992] shows that the history of physics is full of instances in which scientists applied "inferences" that were hardly rigorous, and indeed contradictory. According to Steiner, the same goes, even more so, for central aspects of contemporary quantum mechanics.

In short, some contradictions *are* troubling, and they do lead to tension. The tension stubbornly remains until the contradiction is resolved. However, it seems that other contradictions are not so troubling. Humans have a knack of telling which is which. So non-contradiction does not describe pre-theoretic dispositions in full generality.

From the present perspective, the inference of *ex falso quodlibet* fares even worse. As we saw, Quine wrote that theories, of all sorts, constitute "a fabric of sentences variously associated to one another and to non-verbal stimuli by the mechanism of conditioned response" (Quine [1960, 11]). At the basic level considered in this sub-section, so-called "rules" of inference amount to generalizations concerning conditioning. The rule of *modus ponens*, or *arrow elimination*, is the generalization that once we realize that we accept sentences of the form $P \rightarrow Q$ and P , we automatically become disposed to either accept Q or else retract either $P \rightarrow Q$ or P . The rule is also a disposition to reject the conjunction of $P \rightarrow Q$ and P , if one has rejected Q . So if someone is disposed to accept P and $P \rightarrow Q$ and is also disposed to reject Q , then there is tension. Something must give. Along these lines the rule of *ex falso quodlibet* is a statement that if a (sane) human being finds himself accepting sentences in the form $P, \neg P$, then for any sentence Q , she will either become disposed to accept Q or else to retract at least one of $P, \neg P$.

Note that the second disjunct here is the "law" of non-contradiction, which we have just dealt with. As for the first disjunct, it is simply false that when someone notices a contradiction among his beliefs, he is thereby willing to infer, or is disposed to infer, or thereby accepts, any sentence whatsoever. Relevance logicians have been making this point for some time. As noted, it often happens in the history of science and mathematics (not to mention religion) that theorists find themselves accepting contradictory beliefs. This is not always found to be troubling. To be sure, sometimes contradictions are troubling. Scientists do feel tension and are disposed to revise, in the face of some contradictions. Consider, for example, the wave-particle duality,

or the current state with quantum mechanics and relativity. In typical cases, however, the scientists maintain the contradictory beliefs, for a time, since they do not know a decent resolution. Quantum mechanics and relativity are both well embedded in the web right now. Nevertheless, scientists refrain from inferring arbitrary sentences from this, as would be predicted by the “rule” of *ex falso quodlibet*, as interpreted in this sub-section as a second-nature disposition to infer.⁹ Scientists and mathematicians have a knack for knowing what to infer from their admittedly flawed, contradictory theories. They are indeed conditioned to draw certain inferences, and not others, but the law of *ex falso quodlibet* is not an accurate description of these conditioned inferences.

4.2 Theory. We trust that it is now clear that the principles of non-contradiction and *ex falso quodlibet* are false, if they are understood as descriptions of second-nature, pre-theoretic dispositions to infer and revise. So if these principles of logic are to be accepted by the radical Quinean, as they were by the real Quine, it must be as a result of deliberate logical *theory*, more like “a chapter on chemistry” than “the immemorial doctrine of ordinary enduring middle-sized physical objects”.

Michael Resnik described a process of logic choice that seems to fit the general Quinean mold of theory-building. It is based on Nelson Goodman’s [1955] program of “wide reflective equilibrium”:

One starts with one’s own intuitions concerning logical correctness (or logical necessity). These usually take the form of a set of test cases: arguments that one accepts or rejects, statements that one takes to be logically necessary, inconsistent, or equivalent ... One then tries to build a logical theory whose pronouncements accord with one’s initial considered judgements. It is unlikely that initial attempts will produce an exact fit between the theory and the “data” ... Sometimes ... one will yield one’s logical intuitions to powerful or elegant systematic considerations. In short, “theory” will lead one to reject the “data”. Moreover, in deciding what must give, not only should one consider the merits of the logical theory *per se* ... but one should also consider how the theory and one’s intuitions cohere with one’s other beliefs and commitments, including philosophical ones. When the theory rejects no example one is determined to preserve and countenances none one is determined to reject, then the theory and its terminal set of considered judgements are in ... *wide reflective equilibrium*. (Resnik [1997, 159])

The law of non-contradiction and the rule of *ex falso quodlibet* could be arrived at via a theoretical procedure like the one Resnik describes. One reflects on the meaning of negation, and concludes that true contradictions are impossible, thus sanctioning the law of non-contradiction. It then follows that the rule of *ex falso quodlibet* is truth preserving. To support this further, we have the medieval argument for *ex falso quodlibet*, rediscovered by C. I. Lewis: from P , infer $P \vee Q$. From this, and $\neg P$, infer Q by disjunctive syllogism.

The rule of *ex falso quodlibet* also figures in rational reconstructions of common inference procedures in mathematics. Suppose, for example, that a mathematician wants to draw a conclusion *T* from some premises. She shows that there are three cases, and that *T* holds in two of those. Then she shows that the third case is contradictory. She concludes that *T* is true, given the premises. One natural way to interpret the reasoning is as a proof by cases (or disjunction elimination). The conclusion *T* follows from all three cases, two by explicit reasoning and one by *ex falso quodlibet*.¹⁰

To be sure, dialetheists, relevance logicians, and other non-classicists provide routes to reflective equilibria in which non-contradiction and/or *ex falso quodlibet* are not sanctioned. These logicians resist the reasoning that leads to the law of non-contradiction and they provide other reconstructions of practice (or criticize the practice). For a Quinean, these debates are conducted on the same lines as any other scientific disputation.

We now need to understand how a logic arrived at by theorizing fits into the radical Quine's talk of consequence in terms of conditioning. Accepting any sort of theory—be it chemical, logical, whatever—does not automatically make one conditioned to infer in accordance with it. How can it? To follow one of Quine's examples, suppose that a scientist accepts a chemical theory that if the contents of a certain test tube turn green, then there is copper in it. Suppose also that the scientist observes a green tint in the test tube. This does not *guarantee*, or otherwise entail, that she is disposed to infer that there is copper in it. She may have missed the inference, been inattentive, or simply made a mistake in the reasoning.

We have again broached the troubling matter of normativity. Accepting a chemical or logical theory has normative force, and we do not always live up to our norms. We propose the following, on behalf of the radical Quinean. The acceptance of a theory represents something like a second-order disposition—a disposition to align one's dispositions in accordance with the theory. The acceptance of a theory expresses an *intention* to infer in certain ways (assuming that our Quinean can make peace with this talk of intentions, presumably in terms of further conditioning). Second, acceptance of a theory amounts to a *commitment* to infer in certain ways. The scientist who accepts a theory and then fails to infer in line with it is subject to criticism and correction.

Broadly speaking, criticism and correction are communal matters. Sometimes Quine speaks of dispositions and conditioning concerning groups of people. To continue a passage, noted earlier, from "Two dogmas":

... in this notion of "germaneness" I envisage nothing more than a loose association reflecting the relative likelihood, in practice, of *our* choosing one statement rather than another for revision in the event of recalcitrant experience. For example, *we* can imagine recalcitrant experiences to which we would surely be inclined to accommodate our system by reëvaluating just the statement that there

are brick houses on Elm Street . . . We can imagine other recalcitrant experiences to which we would be inclined to accommodate our system by reëvaluating just the statement that there are no centaurs . . . (Quine [1951, §6], emphasis mine)

The words “our” and “we” here presumably refer to the community of scientists and naturalistically minded philosophers. Does it make sense to speak of group-conditioning, or of the collective dispositions of several people at once, in anything other than an additive way? Groups are made up of individuals, and the various individuals have dispositions and are conditioned to respond in various ways to various stimuli. Perhaps the plural talk refers to patterns of deference and sanction within the community. What it means for a chemical theory or a logical theory to be adopted by a community of scientists is that anyone who fails to infer in accordance with it will be criticized, or is subject to communal sanction. Colleagues will point out the error, scientific journals will refuse to publish such work, etc.

Let’s try this. From the present perspective, a theory is deliberately accepted by a community of scientists once they organize their patterns of sanction and deference in accordance with it. So we now ask if the law of non-contradiction and the inference of *ex falso quodlibet* have been deliberately accepted by the intellectual communities around today, in this sense.

Notice that we are still at the level of description. It is just that the focus is turned to communal practices. Our two logical principles fare no better here than they did in the previous sub-section. A bit worse, actually. Let us start with the community of professional philosophers and logicians—our own peer groups. To be sure, a large group working on truth and other areas infected by paradox do operate on the standard suggested by the law of non-contradiction. Inconsistent theories are not tolerated in those circles. However, in light of the growing number of dialethic and other paraconsistent accounts and explanations of a range of phenomena, we can no longer point to non-contradiction and *ex falso quodlibet* as norms upheld in our own community. Paraconsistent and even dialethic theories appear in the most respected and rigorously refereed philosophy and logic journals and presses. It would be manifestly unfair for a referee attracted to classical logic to reject a paraconsistent treatment of the paradoxes, just because it invokes a paraconsistent logic, or just because it requires the acceptance of a contradiction. As long as paraconsistency remains a live option in our own philosophical exchanges—as long as dialetheists and other paraconsistent logicians are full-fledged members of our community—we cannot claim that, as a matter of deliberate logical theorizing, our own community has adopted classical logic.

When we look to the wider community of scientists, the remarks from the previous sub-section apply at the level of community just as much, if not more, than at the level of individual scientists. It is not correct that the community does not tolerate any contradictions whatsoever. Decades of

wave-particle duality, infinitesimals, and other non-rigorous reasoning bear this out. Ex falso quodlibet fares even worse. There is little evidence that if one does entertain contradictory premises, she is entitled to infer anything whatsoever. Someone who did invoke ex falso quodlibet, willy nilly, in a scientific article that deals with quantum mechanics and relativity would find his work summarily rejected.

To sum up, as a *description* of scientific behavior, non-contradiction and ex falso quodlibet fall far short, whether we focus on individual dispositions or communal practices of deference and sanction. If we are to give the radical Quinean a shot at upholding classical logic, we need to leave the realm of the descriptive altogether. Perhaps Quine was *proposing* that the proverbial “we” adopt the law of non-contradiction and the rule of ex falso quodlibet. The thesis is that classical logic helps make for a fine or improved “world system . . . that is as smooth and simple as may be and that nicely accommodates observations around the edges” (Quine [1986, 100]). In other words, the claim is that an overall world view, a web of belief, that operates according to classical logic is better confirmed, on ordinary scientific grounds, than a web operating with a different logic, other things equal.

In a discussion of bivalence and excluded middle in the context of vagueness, Quine [1981] explicitly takes a route like this. He concedes that imposing classical bivalence on our treatment of vague predicates has its costs. In effect, bivalence leaves us with boundaries that cannot be located (perhaps anticipating epistemicist accounts of vagueness, like those of Timothy Williamson [1994] or Roy Sorenson [1988], [2001]). Quine argues, however, that these costs should be paid, since classical logic has other, compensating virtues.

As noted at the outset, classical logic is advocated by the majority of professional logicians, but hardly any of those good folks are radical Quineans. The question in focus now is whether classical logical theory fares well on *Quinean* grounds for theory acceptance: adequacy to the data, fruitfulness in predictions, simplicity, etc. If the underlying claim could be made out, then for the radical Quine, the community of scientists *ought to* accept classical logic, at least as a regimentation of their practice, even if they occasionally fall short of this norm. The current thesis, then, is that the intellectual community would do well, by established empirical criteria, to align their dispositions, and patterns of deference and censure, in accordance with classical logic.

So how *do* non-contradiction and ex falso quodlibet fare on the Quinean grounds for theory acceptance? On the positive side, it seems to us, at least, that classical logic is simpler than any of its paraconsistent rivals. Moreover, it has a beautiful and well-developed meta-theory. The downside is that classical logic sometimes leaves us powerless when we notice a paradox or contradiction on the web of belief. The law of contradiction assures us that *something* has gone badly wrong—our beliefs *cannot* all be true. But if we do not know how to revise them, we are stuck. Ex falso quodlibet tells us that

we are then committed to every sentence whatsoever. If we drop one or the other of the contradictory beliefs, randomly, to avoid this disaster, we may find ourselves with a much less useful theory. We lose the predictive power enjoyed by the discarded theory.

So from the stated perspective of the radical Quine, the scientist thus has reason to resist classical logic, the law of non-contradiction and *ex falso quodlibet* in particular. The automatic rejection of all contradictions cripples the enterprise, robbing it of explanatory and predictive power.

There are two different ways a scientist might resist the Quinean proposal of regimenting practice in accordance with classical logic. One is to avoid logical theory, or regimentation of inference, altogether. The argument might go as follows:

I've gotten by for so long just inferring on an intuitive level. I have a good feel for what does and does not follow from certain premises. Why shouldn't I continue to rely on this? It has worked well. My practice of inferring by instinct ain't broke. Why fix it? Concerning the so-called "law of non-contradiction", I grant that many contradictions are, or would be troubling, and call for revisions, but I am not convinced yet that all contradictions should be immediately rejected, out of hand—especially if there is no good replacement theory at hand. I have a good feel for when a contradiction creates tension and when it does not. Why shouldn't I just go on with my instincts and training? I lose something by adopting a logical theory. What do I gain?

The objector claims that adopting a logical theory—any logical theory—has *costs*. We can no longer rely on instinct when inferring, but must check our inferences against the theory. It is reasonable to assess the costs of having a logical theory at all.

The Quinean has a ready answer to this. By adopting a rigorously formulated logic, we gain a *system*, a clear and straightforward way to apply the theory and make predictions both concerning inference and concerning the material world. Science itself strives for system, and inference is part of science. The above reply proposes to eliminate or accept contradictions, and accept or reject inferences, in an undisciplined, *ad hoc* manner. That tells against the proposal. The person making the reply might concede this, and claim that his non-system has compensating virtues. It has greater predictive power, based on its track record.

A second way to resist Quine's proposal to adopt classical logic is to adopt a competing, paraconsistent logic instead. This is to demur from the law of non-contradiction and *ex falso quodlibet* in a *disciplined* manner. From the present perspective, the paraconsistent logician and the classicist play the same game, striving for the best system.

Suppose, then, that science has been regimented via classical logic, and assume that the system, so regimented, seems to be working pretty well.

There is still a question of whether the enterprise might function better with a different logic.

As we saw, Quine correctly notes that "... logical truths ... are germane to all topics and thus provide connections" (Quine [1960, 13]). Logic is universally applicable; wherever there is inference, there is logic. So, Quine argues, we have good reason not to tinker with logic when revising our beliefs: "if revisions are seldom proposed that cut so deep as to touch logic, there is a clear enough reason for that: the maxim of minimal mutilation" (Quine [1986, 100]).

Define the *Mutilation Thesis* to be the claim that a change in logic would require drastic changes throughout the web of belief. Quine seems to bank on it, in his insistence on classical logic. The thesis, of course, is that in just about every case imaginable, a less drastic change will always do better to accommodate whatever data led to the proposal to revise our inference patterns. The Mutilation Thesis is a more or less empirical claim about how the web of belief functions at present, and how it would function under various revisions.

We submit that the Mutilation Thesis is outright false. Note, first, that if an inference is valid in most of the developed paraconsistent logics (such as Priest's [1987] LP, Neil Tennant's [1987] CR, and the systems developed in Anderson and Belnap [1975] and Anderson, Belnap, and Dunn [1992]), then it is classically valid. Priest [1987, Chapter 8] defines an inference to be "quasi-valid" if it is classically valid, but not valid in an indicated paraconsistent logic. Quasi-valid inferences are truth preserving in areas that are free from contradiction. So if one is confident that the area one is talking about is consistent, then it is rational to use quasi-valid inferences in that area.¹¹ So if it is rational to be confident that there are no contradictions lurking in the empirical realm, or in mathematics, or in a given chunk of science, then one can reason classically in those areas. So the "mutilation" required by paraconsistent logic is rather minimal. All we have is that one should not reason classically if one has reason to be nervous that a contradiction might be lurking among one's beliefs in a given area. But we knew that much already. *Ex falso quodlibet* breeds disaster in such situations. According to the paraconsistent logician, what we gain by replacing classical logic is a way to proceed when we do suspect, or even know, that we have embraced a contradiction, and do not know what to do about it. So we can have our cake and eat it too. Whatever benefits are claimed for classical logic can be maintained, when it is appropriate to reason that way. In effect, we have a simple dominance argument in favor of paraconsistent logic.

Of course, the paraconsistent logician insists that even in consistent situations, quasi-valid inferences are not *valid*. It is just that it is rational to use them in some contexts. But our radical Quinean does not, or at least should not, care much about *that* distinction. We saw Quine remark that inferences based on chemical theory are not different in kind from logical inferences.

Such is holism. Why should the difference between valid and quasi-valid be any more significant for epistemology than the difference between logic and chemistry?

It might be amusing to speculate how Quine would react to the present considerations, if he found them convincing. Perhaps he would find himself more attracted to classical logic than to the radical holism (or the behaviorism that underlies it). In the spirit of holism, he just might decide to give up the radical holism in favor of classical logic. He might thus become the logic-friendly Quine.

We conclude with a passage from David Lewis [1982, 434-435]:

No truth does have, and no truth could have, a true negation. Nothing is, and nothing could be, literally true and false. This we know for certain, and *a priori*, and without any exception for especially perplexing subject matters ... That may seem dogmatic. And it is; I am affirming the very thesis that Routley and Priest have called into question, and—contrary to the rules of debate—I decline to defend it. Furthermore, I concede that it is indefensible against their challenge. They have called so much into question that I have no foothold on undisputed ground. So much the worse for the demand that philosophers always must be ready to defend their theses under the rules of debate.

Lewis's concern here is with the truth of the principle of non-contradiction, whereas here we are more interested in its potential status as a principle of logic. But the dialectical situations are similar. It should be clear that the radical Quine is not entitled to Lewis's attitude. For Quine, *everything is up for grabs*, at least in principle, and the rules of debate are at least relatively clear. We want the smoothest system that accommodates observations. So when the dialetheist speaks, the radical Quinean must listen. The burden of this paper is that he has little to say in response.

Notes

¹ We are indebted to Graham Priest [2003] for insisting on the distinctions sketched here.

² There are different formulations of the principle of non-contradiction. One is that any sentence in the form $A \& \neg A$ is logically false, and no such sentence is true. Another is that no true sentence has a true negation. These are not equivalent in some paraconsistent logics, under some accounts of truth. The distinctions do not matter here, and we'll continue to speak of "the" law of non-contradiction.

³ Alan Berger [1980, 271] writes, "Quine views logic as a class of statements. But is it more natural to view logic in terms of the deductive interconnections that hold among statements". See also Shapiro [2000].

⁴ In the theme that "indeterminacy begins at home", Quine speaks of "translating" our own discourse, homophonically or otherwise. Presumably, the same canons of translation apply at home as they do in the field. So we must "translate" our past selves as subject to the same logic as we have now. So we can never see ourselves as having revised our logic.

⁵ The first half of Bennett [1958] develops a broadly Quinean notion of "analyticity" along similar lines: a sentence is "analytic" if it has logical connections throughout the web, so much

so that revising it would require massive revisions elsewhere. See also Burgess [2004]. Quine's statement that a change in logic would have ramifications throughout the web, and thus that logic is analytic in Bennett's sense, is a broadly empirical claim. In § 4.2 below, we will examine whether it is true. We will see that it is not.

⁶ Otávio Bueno and Mark Colyvan [2004], and Colyvan [2003], have attempted to sketch such a picture, invoking a non-monotonic logic.

⁷ Of course, there are paraconsistent and relevant logics that maintain the law of non-contradiction, but demur from *ex falso quodlibet*. Issues of relevance would take us too far afield here.

⁸ This is not to say that logic is *about* dispositions. On Quine's view, the subject matter of a given field is whatever is in the range of the bound variables of its truths. So the subject matter of logic consists of whatever logical truths are about, and whatever logical inferences apply to. Since there are logical truths and logical inferences concerning any objects whatsoever, logic is about everything. It has no distinctive subject matter.

⁹ A standard resolution of dilemmas like this is to think of an individual's belief set as chunked, with each chunk consistent. The interpretive issues concerning such rational reconstructions are delicate, and would take us too far afield.

¹⁰ Alternately, one might have the conclusion follow in other ways. We have $(C_1 \vee C_2) \vee C_3$. Learning that C_3 is contradictory amounts to $\neg C_3$. So we conclude $C_1 \vee C_2$, by disjunctive syllogism, and then do a proof-by-cases on that. But the above medieval argument shows that *ex falso quodlibet* follows from disjunctive syllogism and or-introduction (assuming the transitivity of correct inference).

¹¹ It is a delicate matter to give the proper formulation of this principle. It is not sufficient to simply add a premise that the discourse is consistent. If the underlying theory is, in fact, inconsistent, then adding a premise that it is consistent will not make it so, and will not make it "safe" to employ classical logic. See Priest [1987, Chapter 8] and Anderson, Belnap, and Dunn [1992, §80.4].

References

- Anderson, A. and N. Belnap [1975], *Entailment: The logic of relevance and necessity I*, Princeton, Princeton University Press.
- Anderson, A. and N. Belnap, and M. Dunn [1992], *Entailment: The logic of relevance and necessity II*, Princeton, Princeton University Press.
- Bennett, Jonathan [1958], "Analytic-synthetic", *Proceedings of the Aristotelian Society* 59 (1958–9), 163–188.
- Berger, Alan [1980], "Quine on 'alternate logics' and verdict tables", *Journal of Philosophy* 77, 259–277.
- Bueno, Otávio, and Mark Colyvan [2004], "Logical non-apriorism and the law of non-contradiction", in *The law of non-contradiction: new philosophical essays*, edited by in G. Priest, J. C. Beall, and B. Armour-Garb, Oxford, Oxford University Press, 156–175.
- Burgess, J. [1992], "Proofs about proofs: A defense of classical logic", in *Proof, logic and formalization*, edited by Michael Detlefsen, London, Routledge Publishing Company, 8–23.
- Burgess, J. [2004], "Quine, analyticity and philosophy of mathematics", *Philosophical Quarterly* 54, 38–55.
- Colyvan, M. [2003], "Naturalism and the paradox of revisability", presented at the 2003 Australasian Association of Philosophy Conference at the University of Adelaide, Australia.
- Davidson, D. and J. Hintikka [1969], *Words and objections: essays on the work of W. V. Quine*, Dordrecht, D. Reidel Publishing Company.
- Goodman, Nelson [1955], "The new riddle of induction", in *Fact, fiction and forecast*, Cambridge, Massachusetts, Harvard University Press, 59–83.

- Lewis, D. [1982], "Logic for equivocators", *Noûs* 16, 431–441; reprinted in D. Lewis, *Papers in philosophical logic*, Cambridge, Cambridge University Press, 1998, 97–110.
- Priest, G. [1987], *In contradiction: a study of the transconsistent*, Dordrecht, Martinus Nijhoff Publishers.
- Priest, G. [2003], "On alternative geometries, arithmetics, and logics; a tribute to Łukasiewicz", *Studia Logica* 74, 441–468.
- Quine, W. V. O. [1951], "Two dogmas of empiricism", *Philosophical Review* 60, 20–43.
- Quine, W. V. O. [1960], *Word and object*, Cambridge, Massachusetts, The MIT Press.
- Quine, W. V. O. [1969], "Replies", in Davidson and Hintikka [1969], 292–352.
- Quine, W. V. O. [1981], "What price bivalence?", *Journal of Philosophy* 78, 90–95.
- Quine, W. V. O. [1986], *Philosophy of logic*, second edition, Englewood Cliffs, New Jersey, Prentice-Hall.
- Quine, W. V. O. [1991], "Two dogmas in retrospect", *Canadian Journal of Philosophy* 21, 265–274.
- Resnik, M. [1997], *Mathematics as a science of patterns*, Oxford, Oxford University Press.
- Shapiro, S. [1998], "Logical consequence: models and modality", in *The philosophy of mathematics today*, edited by M. Schirn, Oxford, Oxford University Press, 131–156.
- Shapiro, S. [2000], "The status of logic", *New essays on the a priori*, edited by Paul Boghossian and Christopher Peacocke, Oxford University Press, 2000, 333–366; reprinted in part as "Quine on Logic", *Logica Yearbook 1999*, edited by Timothy Childers, Prague, Czech Academy Publishing House, 11–21.
- Sorenson, R. [1988], *Blindspots*, Oxford, Oxford University Press.
- Sorenson, R. [2001], *Vagueness and contradiction*, Oxford, Oxford University Press.
- Steiner, M. [1992], "Mathematical rigor in physics", in *Proof and knowledge in mathematics*, edited by Michael Detlefsen, London and New York, Routledge, 158–170.
- Tennant, N. [1987], *Anti-realism and logic*, Oxford, Oxford University Press.
- Williamson, T. [1994], *Vagueness*, London and New York, Routledge Publishing Company.